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Article

The First Two Years of COVID-19 Hospitalization Characteristics and Costs: Results from the National Discharge Registry

COVID-19 hospitalization in Italy

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Abstract: Background: To date, the COVID-19 pandemic has been the foremost health concern for humankind in the new millennia. This paper aims to describe the related hospitalizations in Italy during the first two years of the health emergency. **Design and methods:** This is a retrospective, population-based study of Italian hospitalizations for patients diagnosed with COVID-19 during the 2020-2021 period, extracted from the National Hospital Discharge Registry. The outcome variables considered include hospital admissions, costs, and length of stay, among other hospitalization-level variables. Costs were estimated through the charges associated with the Diagnosis-Related Group and Major Diagnostic Categories coding system. To these charges was added an extra cost defined by the ministry of health. **Results**: In Italy, there were 357,354 hospitalizations for COVID-19 attributed to 298,856 patients in 2020 and 399,043 hospitalizations for COVID-19 attributed to 333,447 patients in 2021. COVID-19 patients faced a transfer rate thrice that of other patients. Hospitalizations were concentrated predominantly in the northern regions, particularly in the first year. Hospitalization rates varied by age in a sine wave pattern, peaking in the youngest and oldest age groups, with mortality rates escalating with age— tending to remain below 3% for those under 44 but surging to 40% in individuals over 75. The financial impact of COVID-19 hospitalizations was substantial, with total costs reaching €3.97 billion in 2020 and €4.99 billion in 2021. Costs per admission and per day rose, from €11,112 and €807 in 2020 to €12,503 and €844 in 2021, respectively. Excluding the added financial burden of COVID-19, costs would have been notably lower. Hospitalizations involving continuous invasive mechanical ventilation were particularly costly (about 24.000 euros x admission), reflecting the significant resources required for these treatments. **Conclusion**: Implementing a protective pad around the entire health system that leverages networks of family doctors and nurses, connected in real time to the entire health system, can be crucial. Such a network, tasked with supporting the monitoring of the local epidemiological situation, protecting vulnerable individuals also through telehealth visits, and establishing a triage system for infections in the initial phase, can effectively help manage virus spread and protect hospitals from unpredictable waves of admission demand. Strengthening primary health care could be a decisive factor for the future and enhance the system's resilience in facing new challenges.

Keywords: COVID-19; incidence; lethality; negative binomial; moving averages

1. Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was identified for the first time in the late 2019 in the city of Wuhan (Hubei, China). [1] It causes the coronavirus disease 2019 (COVID-19) with symptoms ranging from mild flu-like symptoms to severe pneumonia [2]. The World Health Organization (WHO) declared the outbreak a Public Health Emergency of International Concern from 30 January, 2020 to May 5, 2023 and a pandemic on 11 March 2020 [3]. The virus quickly spread all around the world, and during the first two years of the pandemic (January 2020 ro December 2021), the weekly updated WHO data reported 280,614,414 confirmed

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cases and 5,446,891 deaths[1]. One of the most significant social effects of the pandemic was its profound impact on hospital capacities worldwide [4]. In 2020-2021, the European Centre for Disease Prevention and Control (ECDC) reported 12,563,619 of Covid-19 hospitalizations in Austria, Belgium, Bulgaria, Cyprus, Czechia, Estonia, France, Ireland, Liechtenstein, Lithuania, Luxemburg, Netherland, Romania, Slovakia, Slovenia, Spain[2]. In the same period in US, the Centers for Disease Control and Prevention reported 3,719,818 hospitalizations in the whole country[3]. During the peaks of transmission, health systems in many countries were overwhelmed, and due to the complexity of treating COVID-19 patients, especially in intensive care units, hospitalization costs increased worldwide. A systematic review found that in Germany the total cost of hospitalization in intensive care per patient was 100,789 USD (5). Even if the world was not prepared nor coordinated to such emergency, there was an impressive mobilization of human societies worldwide. Virus lethality of the original strain was quickly estimated by the infection fatality ratio (IFR) assessed through several national serosurveys [6,7]. By the end of 2020, global Medicines Agencies had conditionally approved several vaccines based on different technologies, with others close behind (8,9). Most governments established unprecedented public health policies, such as social distancing, remote working, and lockdowns, to reduce the spread of the virus (10,11). Furthermore, there was an impressive proliferation of mathematical models aimed to predict and manage the pandemic as well as evaluate the implemented policies (12). Italy was the first European country to be hit by the new virus and declared a health emergency status from January 31, 2020 to the 31 of march 2022. The unexpected high speed of transmissions quickly caused hospitals saturation and forced the governmental administration to establish a national lockdown. The hardest period was during the first two years of pandemic, before the vaccination campaign (started in last days of 2020) began to have the desired effects. To increase the health system resilience, it is important to study hospitalizations and the related financial burdens due to COVID-19. This article is part of a broader project focused on assessing hospital characteristics associated with principal occupational respiratory diseases, including COVID-19, which is recognized as an occupational injury under specific conditions when contracted in the workplace. It aims to describe the COVID-19 hospitalizations in Italy and estimate the associated costs with these cases.

2. Methods

2.1. *Settings*

In Italy, the regional administrations have significant autonomy in managing and organizing healthcare services within their territories. They are responsible for allocating the funds received from the central government to hospitals (trough local health units) based on diagnosis-related group (DRG) and Major Diagnostic Categories (MDC) coding systems. Through a decree, The Ministry of Health establishes the National Standard Hospital Charges (NSHC) as the maximum cost per DRG (version 24) in cases of acute care and per MDC in cases of rehabilitation or long-term care cases. For each case defined above, it additionally establishes a length of stay threshold (t) beyond which an additional daily cost is incurred. An additional cost for COVID-19 hospitalizations, based on whether or not patients were admitted to intensive care, was established by the Ministry of Health's decree on August 12, 2021.

2.2. *Participants*

This study included all patients and their corresponding hospitalization episodes in Italy diagnosed with COVID-19 during the years 2020 and 2021.

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[1] https://data.who.int/dashboards/covid19/data?n=c

[2] https://www.ecdc.europa.eu/en/publications-data/covid-19-testing

[3] https://covid.cdc.gov/covid-data-tracker/#trends_weeklyhospitaladmissions_select_00

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2.3. *Outcomes*

The primary outcomes included the annual number of COVID-19 hospitalizations, along with the associated length of hospital stay and costs. Secondary outcomes were the characteristics of both the hospitals and the patients.

2.4. *Data Sources/Measurement*

The ministry of health provided two aggregated datasets from the National Discharge Registry for the years 2020-2021. The first dataset includes the number of patients by demographics, i.e. year, gender, and age groups (0 years; 1-4 years; 5-13 years; 14 years; 15-24 years; 25-44 years; 45-64 years; 65-74 years; 75+ years) and their residence at the regional level. The second dataset expands on this by including the number of hospital admissions and length of stay, categorized by the same demographic variables and further detailed by primary medical treatment (coded by ICD-9-CM), Diagnosis-Related Groups (DRGs, version 24) with distinctions between medical and surgical types, care activity (including pregnancy-related, acute care, long-term care, and rehabilitation), hospitalization regimen (ordinary or day-care), and outcomes at discharge (deceased, transferred, or discharged to residence). For analytical purposes, we combined the age groups 5-13 and 14 years into a single group (5-14 years) and categorized regions into Territorial divisions (North-West, North-East, Centre, South, and major Islands) to facilitate regional comparisons. From the 2020 and 2021 annual discharges reports of the Ministry of Health, we took the total number of hospitalizations, the days of length of stay and the total estimated cost (13,14). Following costs estimates in those reports, we applied the National Standard Hospital Charges (NSHCs) as defined by the Ministry's decree of October 12, 2012 and thresholds (t) as specified in the decree of December 18, 2008. For acute care, NSHC charges are cumulatively expressed for the entire period up to the threshold time and as a daily charge for any period beyond this threshold. For rehabilitation and long-term care, NSHC charges are consistently expressed as daily charges, applicable both within and beyond the threshold period. Since we lack a variable indicating admission to intensive therapy, we have used ICD-9-CM treatment codes, specifically 96.7 (other continuous invasive mechanical ventilation), as a proxy for an intensive care stay. We downloaded the Italian population by age and Territorial division (Northwest, Northeast, Central, South, and Islands) from the site of the Italian Institute of Statistics[4]. Statistics about the whole Italian hospitalizations (number of admissions, length of stay and estimated costs) were taken from the Ministry of Health reports (13,14).

Statistical Analysis

We began by aggregating episodes of hospitalization that resulted in death at discharge, based on patient characteristics. This aggregated data was then merged with the existing patient database to incorporate the number of deceased patients. Within this enhanced dataset, we analyzed the rate of hospitalized patients per population, segmented by year, age, and Territorial division. Additionally, we calculated the percentages of deaths and of male patients.

For the hospitalization dataset specifically, we examined the number of admissions and the total days of hospital stay, along with their respective proportions of the total hospital admissions. Cost assessment was conducted in several steps using the aggregated dataset, which includes the number of admissions (n) and days of stay (GG), segmented by the previously mentioned variables. For each record, based on NSHC charges and threshold times, we associated the corresponding charges within (ch1) and beyond (ch2) the threshold and calculated the cumulative threshold (T) for grouped admissions as:

$$T = t \times n$$

The total number of days exceeding the threshold (diff) for the corresponding admissions was determined by:

[4] https://demo.istat.it/app/?l=it&a=2020&i=POS

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$$diff = \min\{0, GG\text{-}T\},$$

Costs of admission for acute care (*TCA*) were then assessed using the formula:

$$TCA = (ch_1 + diff \times ch_2) \times n$$

Similarly, for rehabilitation and long-term care admissions (*TCRL*), costs were calculated as:

$$TCRL = (min\{GG,T\} \times ch_1 + diff \times ch_2) \times n$$

We also added an extra cost of 3,713 × *n* euros to all group of admissions which were not transferred and 9,697 × *n* of euros to all group of admissions with principal treatments coded as 96.7 in ICD-9-CM. Since the general expenses in the reports (13,14) are calculated net of the extra costs attributed to COVID-19, we added to them our estimates. Finally, 2020 costs were deflated by means of annual consumer price indexes provided by the Italian National Institute of Statistics.

3. Results

Patients' Characteristics

During the initial two years of the COVID-19 pandemic (2020-2021), there were 298,856 hospitalized patients in 2020 and 333,447 in 2021, with a significant concentration in the northern regions, especially during the first year. The hospitalization rate in Northern Italy was twice that of the rest of the country. Females were more prevalent in the 15-44 age group, while males dominated other age groups. Hospitalization rates varied by age, exhibiting a sine wave pattern with peaks observed in infants and the 65-74 years age groups. Mortality rates increased with age, remaining below 3% for individuals under 44 but rising exponentially in older age groups, surging to 40% in those of 75 and older (Table 1).

Table 1. COVID-19 hospitalized patients characteristics.

Territorial division	Age	2020			2021		
		Admission Rate	Deaths (%)	Male (%)	Admission rate	Deaths (%)	Male (%)
Nord-West							
	75+	3.2	40.1	51.2	2.4	31.1	49.0
	65-74	14.1	23.7	65.5	11.6	16.4	60.9
	45-64	6.5	8.4	67.3	5.2	5.4	64.7
	25-44	2.1	1.8	49.2	2.1	0.9	44.8
	15-24	0.8	0.8	47.4	0.8	0.6	45.7
	5-14	0.7	0.4	56.2	0.7	0.2	58.9
	1-4	2.3	0.1	55.1	3.1	0.1	56.4
	0	14.2	0.1	52.8	16.3	0.2	53.8
Nord-East							
	75+	2.7	33.9	48.3	2.6	31.0	48.2
	65-74	9.6	18.2	63.7	11.1	15.5	61.0
	45-64	4.2	6.5	65.3	5.3	5.4	64.8
	25-44	1.6	1.5	49.0	2.0	1.3	51.0
	15-24	0.7	0.4	48.8	0.7	0.6	48.1
	5-14	0.5	0.4	60.3	0.5	0.8	62.6
	1-4	1.5	0.4	60.4	1.9	0.3	57.4
	0	8.0	0.5	56.7	11.3	0.2	51.8
Centre							
	75+	1.6	34.4	48.6	2.0	31.1	47.8
	65-74	7.1	18.9	63.4	10.7	15.8	58.3

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	45-64	3.6	7.7	64.5	6.1	6.0	62.8
	25-44	1.7	1.7	45.9	3.2	1.1	46.6
	15-24	0.7	1.0	47.1	1.2	0.4	47.1
	5-14	0.6	0.2	56.6	1.1	0.2	54.6
	1-4	2.1	0.1	54.4	3.4	0.1	53.5
	0	9.7	0.1	54.8	16.4	0.2	54.3
South							
	75+	0.8	39.8	51.4	1.1	40.1	49.6
	65-74	4.8	25.1	65.2	7.7	25.5	61.1
	45-64	2.5	11.0	67.7	4.0	11.9	63.5
	25-44	1.0	3.3	50.8	1.7	2.9	46.1
	15-24	0.4	1.7	50.4	0.6	1.3	44.9
	5-14	0.3	0.9	57.9	0.4	0.6	54.9
	1-4	2.0	0.2	54.0	3.0	0.0	56.3
	0	6.8	0.6	56.1	8.9	0.0	54.9
Major Islands							
	75+	0.7	34.2	47.7	1.1	36.5	47.2
	65-74	3.9	21.8	61.8	6.6	21.8	58.5
	45-64	2.0	9.4	64.9	3.6	10.1	61.9
	25-44	1.0	2.0	39.6	1.6	1.6	44.5
	15-24	0.6	0.5	41.8	0.8	1.0	42.6
	5-14	0.7	0.3	53.8	1.0	0.5	54.1
	1-4	2.5	0.2	55.3	3.9	0.0	57.7
	0	5.4	0.0	55.8	9.7	0.2	57.0

Hospitalizations Characteristics

The high number of transfers increased the total number of hospitalizations attributed to COVID-19 to 357,354 in 2020 and 399,043 in 2021, representing 5.6% and 5.8% of all admissions, respectively (Table 1). Patients admitted for COVID-19 experienced a transfer rate three times higher (16-17% vs. 5.5-5.7%) than those hospitalized for other reasons. Excluding transfers, COVID-19 admissions and their relative percentages dropped to 4.8% and 5.1% for 2020 and 2021, respectively (Table 1 of supplemental materials). The total days of hospital stay for COVID-19 patients were 4,918,162 in 2020 (10% of the total) and 5,911,253 in 2021 (12% of the total). The mean length of stay was 13.8 days in 2020 and 14.8 days in 2021 for COVID-19 hospitalizations, compared to 7.1 and 6.8 days for other discharges, respectively (Table 2). COVID-19 hospitalizations were almost all in acute care (94% in both years), only a little part underwent to surgical treatments (6.7% in 2020 and 8.4 % in 2021) and day hospital almost tripled in 2021, from 1.1% to 2.9% (data not showed in tables).

Table 2. Number of hospitalizations, days of length of stay and of transfers for covid-19 and non-covid-19 admissions.

Year	COVID-19				Non-COVID-19			
	discharges	Total days	Days x hospitalization	trasfers	discharges	Total days	Days x hospitalization	trasfers
2020	357,354	4,918,162	13.8	62,126	6,151,486	43,852,606	7.1	348,117
2021	399,043	5,911,253	14.8	63,361	6,622,507	44,985,112	6.8	354,714

Hospitalizations Costs and Intensive Care

The estimated total cost for COVID-19 hospitalizations in 2021 euros was 3,971,105,146, in 2020 (11,112 per admission and 807 per day) and 4,989,271,574 in 2021 (12,503 per admission and 844 per day). Without considering the extra financial burden attributed to COVID-19, the hospitalization cost would have been 2,825,083,197 in 2020 (7,906 euros per admission and 574 euros per day) and

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3,690,268,358 in 2021 (9,248 euros per admission and 624 euros per day) (Table 3). COVID-19 Hospitalizations with other continuous invasive mechanical ventilation as the principal treatment were 18,143 (5.1%) in 2020 and 21,255 (5.3%) in 2021. The corresponding mean lengths of stay were 17.5 and 19.7 days, respectively. Compared to other COVID hospitalizations, the length of stay increased by an average of 4 days in 2020 and by 5 days in 2021 (Table 3). Hospitalizations costs for patients with invasive mechanical ventilation amounted to 429,351,427 euros (23,665 euros per admission and 1,355 euros per day) in 2020 and 514,945,622 euros (24,227 euros per admission and 1,229 euros per day) in 20221 (Table 4). The extra financial burden increased the cost of these admissions about of 40%. For the other COVID-19 hospitalizations, the total costs were 3,541,753,719 euros in 2020 (10,441 euros per admission and 770 euros per day) and 4,474,325,952 euros in 2021, with costs per admission and per day also increasing to 11,843 euros and 815 euros, respectively. The extra financial burden increased the cost of these admissions about of 25%.

Table 3. total, x admission and per day hospitalizations cost for COVID-19 and all diagnoses.

Year	COVID-19 costs			All admission costs		
	total	x admission	x day	total	x admission	x day
2020	3,971,105,146	11,113	807	25,430,213,596	3,907	521
2021	4,989,271,574	12,503	844	27,616,154,755	3,933	543

Table 4. total, x admission and per day hospitalizations cost for COVID-19 admissions in intensive care.

Year	Intensive care	Admissions	days	cost		
				Total	x admission	x day
2020						
	No	339,211	4,601,316	3,541,753,719	10,441	770
	Yes	18,143	316,846	429,351,427	23,665	1,355
2021						
	No	377,788	5,492,388	4,474,325,952	11,843	815
	Yes	21,255	418,865	514,945,622	24,227	1,229

3. Discussion

The recent COVID-19 pandemic has highlighted global unpreparedness for managing the consequences of the emergence of a new virus with a high transmission rate. During the peaks of infection waves, many national health systems were pushed to the brink of collapse, and extreme measures to reduce contagion, such as lockdowns, proved to be the only effective countermeasures. These measures significantly impacted economic growth and public health worldwide (15,16). By describing significant hospital characteristics and estimating hospitalization costs, this paper can support effective analyses aimed at improving the resilience of health systems for future challenges. Hospitalization costs for COVID-19 patients have been estimated worldwide, but comparisons among countries are impractical because studies have utilized different methods for calculating the costs. This variability has negatively impacted the comparability of costs across studies (5,17). However, knowing the costs of hospitalizations in a country allows us to better prepare for the future from various points of view, ranging from hospital resilience to compensation for infections of healthcare workers and for workers with a high contact rate with the public. By starting from patients' characteristics, we can note that the sinusoidal-like pattern observed in the admission rates across age groups may be attributed to several factors. For example, infants typically have closer contact with their parents than children aged 1-4 years do, potentially making them more susceptible to household transmission. Additionally, this pattern could partly result from heightened protective measures implemented for infants as compared to children aged 1-14 years. In both cases, conducting widespread testing campaigns and rigorous contact tracing efforts significantly contributes to monitor the virus epidemiology and slowing virus transmission. It is also important to highlight that

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the high percentage of patient transfers could be attributed to the initial hospitals being overwhelmed and that the death rate among the oldest individuals was very high, ranging from 30 to 40%. Without efficient primary care, emergency rooms in hospitals have often become the front line against the virus, thereby overexposing health workers to the risk of infection. Simultaneously, vulnerable individuals have probably not received sufficient protection or treatment during the initial phase of the infection. Finally, the COVID-19 represented the 5.6% of the total admissions, 11% of total length of stay and 17% of the total cost in the considered period. The admission in intensive care more than doubled the cost per hospitalization in both years to almost 23.000-24.000 euros while it increased the daily cost of 1.8 times in 2020 (from 770 to 1355 euros) and of 1.5 times in 2021 (from 815 to 1229 euros). Those figures resume the highest impact the pandemic had on the health system. Especially in the first months of pandemic, hospitals in areas where the virus was spreading faced a tsunami of emerging infections and healthcare and social workers paid a very high cost with a percentage of complaints at work equal to 62% of the total[5]. Implementing a protective pad around the entire health system that leverages networks of family doctors and nurses, connected in real time to the entire health system, can be crucial. Such a network, tasked with supporting the monitoring of the local epidemiological situation, protecting vulnerable individuals also through telehealth visits, and establishing a triage system for infections in the initial phase, can effectively help manage virus spread and protect hospitals from unpredictable waves of admission demand. To strengthen the primary health care could make the difference for the future and could increase the system resilience facing new challenges.

Limitations

This paper has two main limitations. Firstly, we categorized hospitalizations with the ICD-9-CM treatment code of 93.9 as admissions to intensive care, which represent approximately 5% of total hospitalizations instead of the expected 10% (18). Secondly, we did not account for the costs associated with waiting for hospital beds for acute COVID-19 patients nor the costs related to waiting in emergency departments for the management of confirmed and suspected COVID-19 cases.

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References

1. Klein, S., Cortese, M., Winter, S.L., Wachsmuth-Melm, M., Neufeldt, C.J., Cerikan, B., Stanifer, M.L., Boulant, S., Bartenschlager, R. and Chlanda, P., 2020. SARS-CoV-2 structure and replication characterized by in situ cryo-electron tomography. Nature Communications, 11(1), pp.1-10.
2. Barth, R.F., Buja, L.M. and Parwani, A.V., 2020. The spectrum of pathological findings in coronavirus disease (COVID-19) and the pathogenesis of SARS-CoV-2.
3. Cucinotta, D., & Vanelli, M. (2020). WHO declares COVID-19 a pandemic. Acta Bio Medica: Atenei Parmensis, 91(1), 157.

[5] https://www.inail.it/cs/internet/comunicazione/covid-19-prodotti-informativi/report-covid-19.html

 doi:10.20944/preprints202403.0676.v1

4. Ridde, V., Traverson, L., & Zinszer, K. (2023). Hospital resilience to the COVID-19 pandemic in five countries: a multiple case study. Health Systems & Reform, 9(2), 2242112.
5. Gholipour, K., Behpaie, S., Iezadi, S., Ghiasi, A. and Tabrizi, J.S., 2023. Costs of inpatient care and out-of-pocket payments for COVID-19 patients: A systematic review. *Plos one*, *18*(9), p.e0283651.
6. Brazeau, N., Verity, R., Jenks, S., Fu, H., Whittaker, C., Winskill, P., Dorigatti, I., Walker, P., Riley, S., Schnekenberg, R.P. and Heltgebaum, H., Report 34: COVID-19 infection fatality ratio: estimates from seroprevalence.
7. O'Driscoll, M., Ribeiro Dos Santos, G., Wang, L., Cummings, D.A., Azman, A.S., Paireau, J., Fontanet, A., Cauchemez, S. and Salje, H., 2021. Age-specific mortality and immunity patterns of SARS-CoV-2. *Nature*, *590*(7844), pp.140-145.
8. Li Y, Tenchov R, Smoot J, Liu C,Watkins S, Zhou Q. A comprehensive review of the global efforts on COVID-19 vaccine development. ACS Central Sci. (2021) 7:512–33. doi: 10.1021/acscentsci.1c00120
9. Francis AI, Ghany S, Gilkes T, Umakanthan S. Review of COVID-19 vaccine subtypes, efficacy and geographical distributions. Postgrad Medical J. (2022) 98:389–94. doi: 10.1136/postgradmedj-2021-140654
10. Murphy, C., Lim, W. W., Mills, C., Wong, J. Y., Chen, D., Xie, Y., ... & Donnelly, C. A. (2023). Effectiveness of social distancing measures and lockdowns for reducing transmission of COVID-19 in non-healthcare, community-based settings. Philosophical Transactions of the Royal Society A, 381(2257), 20230132.
11. Ferrante P (2022) The first 2 years of COVID-19 in Italy: Incidence, lethality, and health policies. Front. Public Health 10:986743. doi: 10.3389/fpubh.2022.986743
12. Ferrante P (2023) Editorial: Lessons and policy consequences of mathematical modeling in relation to ongoing pandemics. Front. Public Health 11:1281493. doi: 10.3389/fpubh.2023.1281493
13. Italian Ministry of health., 2022. Rapporto annuale sull'attività di ricovero ospedaliero (Dati SDO 2020). Disponibile su: https://www.salute.gov.it/imgs/C_17_pubblicazioni_3277_allegato.pdf.
14. Italian Ministry of health., 2023. Rapporto annuale sull'attività di ricovero ospedaliero (Dati SDO 2021). Disponibile su: https://www.salute.gov.it/imgs/C_17_pubblicazioni_3410_allegato.pdf.
15. Naseer, S., Khalid, S., Parveen, S., Abbass, K., Song, H. and Achim, M.V., 2023. COVID-19 outbreak: Impact on global economy. Frontiers in public health, 10, p.1009393.
16. Luijten, M.A., van Muilekom, M.M., Teela, L., Polderman, T.J., Terwee, C.B., Zijlmans, J., Klaufus, L., Popma, A., Oostrom, K.J., van Oers, H.A. and Haverman, L., 2021. The impact of lockdown during the COVID-19 pandemic on mental and social health of children and adolescents. Quality of Life Research, 30(10), pp.2795-2804.
17. Rocha-Filho, C. R., Martins, J. W. L., Lucchetta, R. C., Ramalho, G. S., Trevisani, G. F. M., da Rocha, A. P., ... & Trevisani, V. F. M. (2022). Hospitalization costs of coronaviruses diseases in upper-middle-income countries: A systematic review. PLoS One, 17(3), e0265003.
18. Istituto Superiore di Sanità. Epidemia COVID-19. Aggiornamento nazionale: 28 dicembre 2021. (2021). https://www.epicentro.iss.it/coronavirus/bollettino/Bollettino-sorveglianza-integrata-COVID-19_28-dicembre-2021.pdf (last accessed 03/03/2024)